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FINAL REPORT

NUTRITION VALUE OF WHEAT SCREENINGS FOR LAYING HENS

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Final Report

Nutritional value of wheat screenings for poultry

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ABSTRACT

The Saskatchewan grain industry is rapidly adopting a process of cleaning cereal grains at inland terminals rather than at export ports. This situation has increased the provincial wheat screening supplies available for local markets. The primary advantages of these changes are the reduction of grain transportation costs and the development of a screening utilization industry within the province. One potential market for wheat screenings is the poultry industry, since it uses a high proportion of cereal grains in its diets. Wheat screenings could be used to replace a substantial quantity of the cereals in poultry diets. In order to maximize the value of wheat screenings and to attract new markets, the nutritional value of wheat screenings needs to be compared to cereal grains of known value, such as wheat. The objective of this research was to evaluate the nutritional value of two wheat screenings samples derived from independent sources. Nutritional evaluation included the determination of botanical composition, nutrient digestibility and feeding trials using broiler chickens and laying hens. Both wheat screenings samples contained high levels of wheat (cracked, small kernels; 88.2% and 90.4%), and wild buckwheat as the second most important fraction. The samples contained over 15% protein and their apparent metabolizable energy (AME) values ranged from 3023 to 3107 kcal/kg (as is basis). Amino acid content and balance in wheat screening samples were superior to previous analyses completed in our lab of 16 wheat cultivars. In addition, the amino acids were highly available to the broiler chicken (range: WS1 - 86-97%; WS2 - 76-94%). In the broiler feeding trial, no significant differences were found in growth, feed efficiency and mortality between a wheat control diet and diets where wheat screenings totally replaced wheat. Similarly, wheat screenings replaced wheat up to 50% of the total diet in a laying hen trial without effect on egg production, egg quality and mortality. These data indicate that high quality wheat screenings have good nutritional value for poultry and can be used at relatively high levels in poultry diets.

EXECUTIVE SUMMARY

Objectives

Research was designed to study the nutritive value of wheat screenings in poultry diets with the following objectives:

1. To evaluate the availability of nutrients in wheat screenings for broiler chickens and leghorn hens.
2. To determine the effect of wheat screenings on the performance of broiler chickens and laying hens.
3. To add monetary value to coarse grain screenings by the process of segregation and target market development

The results of this research have allowed practical recommendations to be developed on incorporation of wheat screenings into the diets of broiler chickens and leghorn hens.

MAJOR FINDINGS

1. The two wheat screening samples, derived from independent sources, differed in composition. The portions of wheat were well above the minimal requirement of the Canada Feeds Act for No.1 wheat screenings in both samples. One sample contained 90 % of wheat while the other contained 88.2%. Wild buckwheat was the second most important component in both samples. Numerous other species, such as peas, rye, and

small weed seeds were found only in one sample. The variation in botanical composition between the samples did not significantly affect performance when wheat screenings were incorporated in broiler and laying hen diets.

2. Wheat screenings contained substantially more protein (amino acids) and fat than the average of the wheat cultivars analyzed previously in our lab. The samples of wheat screenings also had higher relative levels of key essential amino acids than wheat, indicating improved protein quality as well as quantity.
3. The apparent metabolizable energy (AME) values of the two wheat screening samples were 3023 and 3107 kcal/kg. These values are similar to a lower energy wheat.
4. The availability of amino acids in wheat screenings was high. There were significant differences between wheat screening samples in amino acid digestibility, however, this did not appear to affect the performance of the birds in production experiments.
5. Wheat screenings may be included in broiler chicken diets up to complete replacement of wheat without negatively affecting growth, feed efficiency, and mortality. Wheat screenings may be included in laying hen diets up to 50% of the total diet without negatively affecting egg production, egg quality and mortality.

CONCLUSION

The compositions of wheat screenings used in this experiment were relatively consistent. The minor variation found did not significantly affect the performance of broiler chickens or laying hens. However, variability is possible and likely in screenings samples from other sources or at other times. Therefore interpretation of data must be specific to the samples that were used in this research. The samples used in this research had a nutritional value suitable for broiler chickens and for laying hens. Crude protein, amino acid digestibility, and metabolizable energy of wheat screenings allow up to total replacement of wheat in balanced broiler chicken diets, and up to 50% of the total diet in balanced leghorn hen diets. Because more variability may be found in other samples of wheat screenings, it may be advisable to restrict inclusion in poultry diets to less than 40% unless quality (composition) is assessed in advance.

Nutritional value of wheat screenings for broiler chickens and leghorn hens

Introduction

In Western Canada, the grain industry is rapidly changing its management practices by having more cereal grains cleaned directly at inland terminals rather than at export ports. After harvesting, the wheat is cleaned in order to separate broken kernels, weed seeds, chaff, etc., from the whole kernels. The primary advantages are the reduction of grain transportation costs due to a reduction of volume shipped and the development of a screening utilization industry within the province. Wheat screenings are defined under the Canada Feeds Act (1967) and shall contain: (1) not less than 35% broken or shrunken grain or both, (2) not more than 7% of crude fiber, (3) not more than 3% of small weed seeds, chaff, hulls and dust, (4) not more than 6% small weed seeds, chaff, hulls, dust, wild and domestic mustard, and rapeseed, (5) not more than 8% wild oats, (6) and wild buckwheat and small portions of other seeds of less value. Wheat screenings, which contain a high proportion of cereal grains, are sold at a price below their nutritional value. Wheat screenings could be used to replace a substantial portion of cereal in the diet of poultry and, therefore, could reduce production costs for poultry producers.

The nutritional value of wheat screenings is determined by their composition. Shrunken and broken wheat kernels should have nutritional value similar to wheat and therefore higher levels of wheat are advantageous. Weed seeds represent a potential nutrient supply but can also be a source of anti-nutrients that could negatively affect animal production. Information is lacking on the nutritional value of weed seeds but wild buckwheat appears to be a suitable feed ingredient. Another potential undesirable effect of feeding screenings is germination of weed seeds after excretion in animal feces and deposition on cropland. Germination of small weed seeds is usually maintained unless these seeds are very finely ground. A common practice of coarse grinding feedstuffs used in mash diets would not eliminate germination and this may cause a problem if the manure is used in crop fertility programs. Again the level and type of weeds found in wheat screenings will differ in botanical composition and nutrient content.

Previous research has suggested that wheat screenings can be used successfully in poultry feeding. In a study by Proudfoot and Hulan (1988) found no significant effect on growth and feed efficiency of broiler chickens when 64 different wheat screening samples collected over a three year period represented up to 45% of the diet. The samples ranged in a protein content ranging from 12.2 to 14.8%. Stapleton *et al.* (1980) studied five different commercial samples of wheat screenings containing from 67 to 84% wheat, 12.2 to 14.6% protein, 4 to 12% wild buckwheat and 5 to 11% rapeseed. In feeding studies with broiler chickens to four weeks of age, no significant effect of wheat screenings was seen on body weight and feed efficiency. Proudfoot and Hulan (1986) found no significant differences in egg production, egg weight, shell quality, yolk quality, and feed efficiency when adult leghorn hen diets contained up to 45% of the same 64 wheat screening samples used in the broiler trial.

The above data indicate a high degree of potential for the use of wheat screenings in poultry diets. Therefore, the following study was designed to study the nutritive value of wheat screenings in broiler chicken and laying hen diets, and to determine the relative nutritional value of wheat screenings in comparison to wheat.

Materials and Methods

Experiment 1:

Two commercial wheat screening samples were obtained from different inland terminals. Our only stipulation to the two plants was that we receive No. 1 wheat screenings appropriate for monogastric species. The two samples were chemically analyzed for key nutritional characteristics (moisture, protein, ether extract, amino acids). In turn, the two samples were used in a nutrient retention experiment with broiler chickens. A total of 100 male broiler chickens were placed in battery cages and used to determine the apparent metabolizable energy (AME) and amino acid availability of the wheat screening samples. Chicks were fed a commercial starter diet until 27 days of age and were kept under continuous light. At 25 days of age, birds were sorted and placed in grow-out cages where they were further divided into 3 groups of 12 replications with each replication having 2 birds. Birds were housed under 16 hours of light per day for the remainder of the experiment. From 27 to 34 days of age, a basal diet containing corn, soybean meal, canola oil and vitamins and minerals was used as the reference diet to determine the AME of the wheat screening samples. The two wheat screening samples replaced this basal diet as the test ingredients (Table 1). The diets, in mash form, and water were provided *ad libitum* throughout the experiment. At 34 days of age, feces and terminal ileal contents (mid-way between the ileal cecal junction and Meckel's diverticulum and 2 cm anterior to the ileal cecal junction) were collected. Ileal samples and feces were freeze-dried and oven dried at 55°C, respectively, prior to analysis. Calculations to determine AME, based on feces, were performed according to the procedure of Bartov (1995). Amino acid digestibilities were determined using ileal samples and calculated according to the procedure of Ten Doeschate et al. (1993). Botanical composition for each wheat screening sample was done at the Agriculture Canada laboratory in Saskatoon, Saskatchewan.

Experiment 2:

The risk of weed seed germination was studied to determine safe manure management for the protection of the environment. Trays were placed under the cages during experiment 1 to collect fresh manure. Manure samples were pooled and placed in a 10% bleach solution for 10 minutes to eliminate micro-organism content, then washed in warm water to increase water and gas permeability (Hartmann *et al.* 1997). The manure was placed in sterilized vermiculite at room temperature for one week. Moisture content and signs of germination were monitored on a daily basis.

Experiment 3:

A total of 1980 female broiler chickens were housed in straw litter pens. Each dietary treatment had 6 replications (55 birds each) for a total of 330 birds per treatment. Birds were raised under an increasing lighting program according to Classen *et al.* (1991). The same wheat screening samples used in experiment 1 were fed at graded levels of 0%, 25%, 50% of the diet and at total replacement of the wheat for the experimental period of 36 days. Total replacement of the wheat in the diet was only done with the wheat screenings sample 1 because of space limitations in the facility. Starter and grower diets were formulated to be isoenergetic and isonitrogenous (Table 2). Diets, in crumble form, and water were provided *ad libitum* during the experiment. Each bird received 1 kg of starter diet before receiving the grower diet. The grower diet was introduced as soon as the starter diet was consumed. Body weight and feed efficiency were recorded at 21 and 36 days of age. Mortality was recorded daily.

Experiment 4:

A total of 750 laying hens from two different strains, 375 hens from each strain, were housed in battery cages and used in this experiment. Each dietary treatment was replicated 10 times with each replication using 15 hens for a total of 150 hens per treatment. The same wheat

screening samples used in experiment 1 were fed at graded levels of 0%, 25%, and 50% of the diet for a period of 15 weeks, from 20 to 35 weeks of age (Table 3). Diets, in mash form, and water were provided *ad libitum* during the experiment. Egg production was measured 5 days per week and corrected to a full week of production. Feed intake, egg weight, and specific gravity were recorded at 24, 28, 32, and 35 weeks of age. Body weight was measured at 30 and 35 weeks of age. Mortality was recorded on a daily basis. Albumen (Haugh unit) and yolk quality were measured at 35 weeks of age using the Technical Services and Supplies Egg Quality Control System^a.

For experiments 1, 3 and 4, statistical analyses were computed using SAS Institute Inc. (1990). In the three experiments, variables were analyzed using a simple ANOVA. A one-way analysis of variance with apriori-contrast was used to determine significant differences between wheat screening samples in experiment 3. Significant difference was established at $P < 0.05$.

Results and Discussion

Experiment 1:

Examination of botanical composition revealed differences between the two samples of wheat screenings (Table 4). Differences included the nature of wheat cultivars and the type of weed seeds in the samples. The proportion of wheat in both samples was high (88.2 to 90.5%) and considerably higher than previous research reports such as Biely and Pomeranz (1975). The primary weed seed was wild buckwheat found at levels of 4.5 and 6.3%. Other weed seeds were found at levels less than 1.5%, and wheat screenings sample 2 contained more species of weed seeds than wheat screenings sample 1.

The chemical analyses showed the crude protein content in the wheat screening samples 1 and 2 to be 15.77% and 15.19%, respectively (Table 5). These values are higher than the average crude protein content of wheat and are in accordance with the findings of Stapleton *et al.* (1980). Not only were the levels of protein and amino acids in the wheat screenings higher but the relative proportions (g/16g of N) of important essential amino acids were also higher. This appears to be a potential significant advantage of wheat screenings over wheat. It would be of valuable to study this advantage further in a larger number of wheat screenings samples. The fat content of the wheat screenings was also higher than found in wheat. The difference was small but would contribute extra energy to wheat screenings.

The AME values for the wheat screenings samples were different (3107 vs 3023 kcal/kg) which is a reflection of their different composition (Table 6). The cultivars of wheat, the quantity of wheat, and the type of weeds present in the samples influenced the AME of the samples. The AME values are still relatively high and are similar to lower energy wheat. The ileal protein digestibility was not significantly different between the two samples (Table 6). The wheat screening samples had significantly different amino acid digestibilities, except in the case of the cystine, which was the same for both the samples. The digestibility of amino acids in sample 1 was better than sample 2 (Table 7). Again the digestibility values were high but the data shows the importance of sample composition in determining nutritional value.

Experiment 2:

The germination test showed no signs of growth after one week. This would indicate that the grinding during feed manufacturing and/or by the gizzard in the bird eliminated the risk of

^a Technical Services and Supplies-TSS, Chessingham Park, Dunnigton, York, YO1 5SE England

germination of weed seeds present in wheat screenings. However, small weed seeds that can be present in wheat screenings may not be affected by the feed processing and the gizzard, and therefore end up on fields during manure handling. More extensive investigation of this aspect of wheat screenings use is required to ensure that this is not a problem in feeding poultry.

Experiment 3:

Dietary treatment did not affect broiler average body weight gain for the periods of 0 to 21 days, 21 to 36 days or 0 to 36 days and consequently body weight at 21 or 36 days of age (Table 8). Feed intake was consistent for the treatments throughout the experiment. There were no significant effects of dietary treatment on feed efficiency for the experimental periods (Table 8) and mortality rates were low and were not affected significantly by dietary treatment. Apriori-constrasts indicated a significant difference between the two wheat screening samples for feed intake between 21 days and 36 days of age (Table 8). This difference may be explained by the lower energy content of sample 2, and the higher associated feed intake. The two samples however, did not affect feed intake during the other periods. When the wheat was compared to the two screening samples, apriori-contrast studies found a better feed efficiency for the wheat screening samples during the period 21 days to 36 days of age. A significant difference in mortality was found between the two wheat screenings samples from 0-36 days of age. However, mortality was low and values for both wheat screenings samples were not different than for birds fed the wheat control treatment. These performance results are in accordance with the findings of Bragg and Biely (1977).

In this study, the variability in botanical composition and nutrient content observed in the wheat screening samples only showed a significant effect on feed intake between 21 days and 36 days of age. All other performance criteria were not significantly affected by the difference in the botanical composition. The results of this study indicate that wheat screenings may be used to replace wheat in balanced broiler chicken diets without affecting performance.

According to Proudfoot and Hulan (1988), the outer layer of wild buckwheat leaves black flecks on the carcass during processing and may increase the incidence of downgrading at the slaughter plant. Whether this is still a concern today needs confirmation and is likely affected by the level of wild buckwheat in the screenings and in turn the level of screenings in the diet. If wild buckwheat levels are high and a high proportion of wheat screenings are used in the diet, it may be desirable to withdraw the wheat screenings from the finisher diet.

Experiment 4:

Dietary treatment did not affect the weight gain, egg production or egg quality of laying hens (Tables 9 and 10). These results are in accordance with the findings of Proudfoot and Hulan (1986). Dietary treatment did affect feed intake with hens fed 50% wheat screenings consuming less feed than birds fed the wheat control or 25% wheat screening diets. This effect was significant for the last 7 weeks of the trial. As a consequence, estimates of feed efficiency (feed:egg mass ratio; feed per dozen eggs) for these treatments was numerically lower than for the control treatment. In the case of feed per dozen eggs, this effect approached significance. Although reduced feed intake seen in this experiment actually resulted in a benefit because of improved feed efficiency, this finding may be due to a number of reasons. These include misjudging the energy content of the screenings, a factor in wheat screenings affecting palatability and/or a toxic component in weed seeds. Based on this finding and the potential variability of screening samples, it is likely advisable to restrict wheat screenings to less than the 50% level used in this research. Having said that, the data from this laying hen experiment are supportive of Experiments 1 and 3 which demonstrated a high nutritional value for wheat screenings as a poultry feed.

Laying hen genotype affected most production characteristics including egg production, feed per dozen eggs, egg weight, egg shell thickness (estimated by specific gravity), albumen quality, feed intake, body weight gain and mortality (Tables 9 and 10). These effects are largely recognized as characteristics of these strains. More relevant to the objectives of this study was the finding that there were no interactions between dietary treatment (wheat screenings inclusion) and hen genotype. This indicates that wheat screenings effects are independent of the genotypes used in this study.

Summary

Wheat screenings have an approximate metabolizable energy value of 3050 kcal/kg, an approximate crude protein value of 15.4%, and an ileal protein digestibility of approximately 82%. These characteristics allowed the wheat screenings to be incorporated in broiler chicken diets up to total replacement of wheat and up to 50% inclusion in laying hen diets. Wheat screening samples vary in botanical and nutrient compositions according to their source of origin; however, the variability in this study did not affect broiler chicken and laying hen performance. However, because of sample variation, the levels of inclusion used in this study may be too high for samples containing less wheat, and/or more and different types of weed seeds. At this moment the effects of the weed seeds present in screenings samples on poultry performance are not clear. For these reasons, it is recommended that a maximum of 40% wheat screenings be used in broiler chicken and laying hen diets. It would be beneficial for the wheat screenings industry to regularly test the chemical and botanical composition of wheat screening samples so as to estimate the value of their products and to encourage poultry producers to use wheat screenings in their diets. The process of grinding should minimize the risk of weed seed propagation but further testing is required to ensure that feeding screenings does not result in "recycling" of weeds on Saskatchewan farms.

Sample uniformity remains a potential risk when using wheat screenings. Further research on the nature of the uniformity would be beneficial to the livestock industry. Questions to be asked include: the amount of wheat and the nature of weed seeds (large vs small; species) that can be placed in samples destined for monogastric species (specific screening design), the species of weeds that are found throughout the province, the nutritional and anti-nutritional factors found in weed species, and the uniformity of the superior amino acid balance found in screenings used in this study.

Wheat screenings are a valuable alternative to feeding poultry in this province. The use of wheat screenings improves the competitiveness of our livestock producers and reinforces the value of cleaning grain within the province.

References:

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Table 1. Composition of wheat screening (WS) diets for the determination of AME and amino acid digestibility (Experiment 1).

Diets	Basal	WS 1	WS 2
		%	
Corn	55.82	20.30	20.30
Soybean meal	32.99	12.00	12.00
Canola oil	5.49	2.00	2.00
WS 1 ¹	0.00	60.00	0.00
WS 2 ²	0.00	0.00	60.00
Enzyme ³	0.10	0.10	0.10
Limestone	1.95	1.95	1.95
Dicalcium Phosphate ⁴	1.27	1.27	1.27
Salt	0.28	0.28	0.28
Vit. Min. premix ^{5,6}	0.50	0.50	0.50
Choline chloride	0.10	0.10	0.10
Acid insoluble ash	1.50	1.50	1.50

¹ Wheat Screening sample 1.

² Wheat screening sample 2.

³ Avizyme 1200, Finnfeeds International Limited, Marlborough, Wiltshire, UK, SN8 1XN.

⁴ Dicalcium phosphate: 15 % Ca, 21 % P.

⁵ Supplied per kilogram of diet: vitamin A (retinyl acetate + retinyl palmitate), 11000 IU; vitamin D₃, 2200 IU; vitamin E (dl- α -tocopheryl acetate), 300 IU; menadione, 2.0 mg; thiamine, 1.2 mg; riboflavin, 6.0 mg; niacin, 60 mg; pyridoxine, 4 mg; vitamin B₁₂, 0.02 mg; pantothenic acid, 10.0 mg; folic acid, 0.6 mg; and biotin, 0.15 mg.

⁶ Supplied per kilogram of feed: iron, 80 mg; zinc, 80 mg; manganese, 80 mg; copper, 10 mg; iodine, 0.8 mg; and selenium, 0.3 mg.

Table 2. Composition of diets for broiler chickens (Experiment 2).

	Starter						Grower					
	1	2	3	4	5	6	1	2	3	4	5	6
	%											
Wheat	61.71	39.65	16.59	0.00	39.10	15.47	69.15	46.08	23.01	0.00	45.52	21.89
WS 1 ¹	0.00	25.00	50.00	67.98	0.00	0.00	0.00	25.00	50.00	74.94	0.00	0.00
WS 2 ²	0.00	0.00	0.00	0.00	25.00	50.00	0.00	0.00	0.00	0.00	25.00	50.00
SBM ³	30.10	27.67	25.52	23.98	28.19	26.58	23.54	21.39	19.25	17.11	21.92	20.30
Canola oil	3.39	3.28	3.43	3.54	3.34	3.56	3.11	3.26	3.42	3.57	3.33	3.54
Enzyme ⁴	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Limestone	1.90	1.92	1.93	1.93	1.91	1.92	1.85	1.86	1.87	1.88	1.85	1.86
Dical.phos. ⁵	1.10	1.09	1.10	1.10	1.09	1.10	1.00	1.00	1.01	1.01	1.00	1.01
Vit.Min premix ^{6,7}	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
NaCl	0.30	0.29	0.29	0.29	0.30	0.30	0.26	0.26	0.25	0.25	0.26	0.26
Choline chloride	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
DL-Met	0.17	0.16	0.17	0.17	0.16	0.15	0.15	0.15	0.15	0.15	0.14	0.14
L-Lys HCL	0.04	0.08	0.13	0.16	0.06	0.09	0.10	0.15	0.19	0.24	0.12	0.15
Coccistac	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Stafac	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Calculated values												
AME, kcal/g	3.000	3.000	3.000	3.000	3.000	3.000	3.050	3.050	3.050	3.050	3.050	3.050
Protein, %	22.00	22.00	22.00	22.00	22.00	22.00	20.00	20.00	20.00	20.00	20.00	20.00
Calcium, %	1.00	1.00	1.00	1.00	1.00	1.00	0.95	0.95	0.95	0.95	0.95	0.95
Available	0.42	0.42	0.42	0.42	0.42	0.42	0.40	0.40	0.40	0.40	0.40	0.40
Phosphorus, %												
ARG, %	1.446	1.424	1.404	1.390	1.462	1.480	1.277	1.258	1.238	1.218	1.295	1.314
LYS, %	1.200	1.200	1.200	1.200	1.200	1.200	1.100	1.100	1.100	1.100	1.100	1.100
MET, %	0.486	0.480	0.480	0.480	0.480	0.480	0.440	0.440	0.440	0.440	0.440	0.440
MET+CYS, %	0.820	0.848	0.881	0.905	0.855	0.896	0.308	0.286	0.265	0.243	0.289	0.270

¹ Wheat screening sample 1.² Wheat screening sample 2.³ Soybean meal.⁴ Avizyme 1200, Finnfeeds International Limited, Marlborough, Wiltshire, UK, SN8 1XN.⁵ Dicalcium Phosphate: 15 % Ca, 21 % P.⁶ Supplied per kilogram of diet: vitamin A (retinyl acetate + retinyl palmitate), 11000 IU; vitamin D₃, 2200 IU; vitamin E (dl- α -tocopheryl acetate), 300 IU; menadione, 2.0 mg; thiamine, 1.2 mg; riboflavin, 6.0 mg; niacin, 60 mg; pyridoxine, 4 mg; vitamin B₁₂, 0.02 mg; pantothenic acid, 10.0 mg; folic acid, 0.6 mg; and biotin, 0.15 mg.⁷ Supplied per kilogram of feed: iron, 80 mg; zinc, 80 mg; manganese, 80 mg; copper, 10 mg; iodine, 0.8 mg; and selenium, 0.3 mg.

Table 3. Composition of laying hen diets (Experiment 4).

	1	2	3	4	5
	%				
Wheat	51.23	35.61	17.93	35.09	16.90
WS 1 ¹	0.00	25.00	50.00	0.00	0.00
WS 2 ²	0.00	0.00	0.00	25.00	50.00
SBM ³	19.81	15.65	13.33	16.12	14.27
Barley	15.00	10.00	5.00	10.00	5.00
Limestone	9.34	9.36	9.37	9.36	9.37
Tallow	1.23	1.23	1.40	1.27	1.48
Canola Oil	1.18	0.94	0.78	0.96	0.81
Dical. Phos. ⁴	1.08	1.08	1.07	1.08	1.07
Laver Premix ⁵	0.50	0.50	0.50	0.50	0.50
Sodium Chloride	0.30	0.29	0.28	0.29	0.28
DL-Met	0.13	0.14	0.14	0.13	0.12
L-Lys HCL	0.00	0.03	0.04	0.01	0.00
Choline Chloride.	0.10	0.10	0.10	0.10	0.10
Enzyme Wheat ⁶	0.10	0.10	0.10	0.10	0.10
Calculated Values					
AME, kcal/g	2.750	2.773	2.787	2.752	2.744
Protein, %	17.58	17.59	17.54	17.59	17.53
Calcium %	3.80	3.80	3.80	3.80	3.80
Available	0.42	0.42	0.42	0.42	0.42
Phosphorus, %					
ARG, %	1.044	1.092	1.073	1.129	1.148
LYS, %	0.831	0.845	0.828	0.845	0.830
MET, %	0.383	0.405	0.399	0.403	0.396
MET+CYS, %	0.692	0.842	0.896	0.848	0.903

¹ Wheat screening sample 1.² Wheat screening sample 2.³ Soybean meal.⁴ Dicalcium Phosphate: 15 % Ca, 21 % P.⁵ Supplied per kilogram of diet: vitamin A (retinyl acetate + retinyl palmitate), 8000 IU; vitamin D₃, 3000 IU; thiamine, 1.5 mg; vitamin B₁₂, 0.012 mg; pantothenic acid, 8 mg; vitamin E (dl- α -tocopheryl acetate), 250 IU; folic acid, 0.5 mg; biotin, 0.06 mg; niacin, 30 mg; riboflavin, 5.0 mg; menadione, 1.5 mg; iodine, 0.8 mg; copper, 10 mg; iron, 80 mg; zinc, 80 mg; manganese, 80 mg; selenium, 0.3 mg; ethoxyquin, 0.625 mg; zinc, 80 mg; and pyridoxine, 1.5 mg.⁶ Avizyme 1200, Finnfeeds International Limited, Marlborough, Wiltshire, UK, SN8 1XN.

Table 4. Botanical composition of wheat screening samples.

Composition %	WS1 ¹	WS2 ²
Wheat	90.46	88.22
Wild buckwheat	4.46	6.31
Argentine rapeseed	1.12	1.39
Peas	--	1.08
Wild oats	1.08	0.45
Barley	0.93	0.07
Canary seed	0.08	0.06
Slender wheatgrass	0.02	--
Flax	0.16	0.60
Polish rapeseed	0.30	0.04
Rye	0.12	--
Juncea	0.02	0.03
Hempniete	0.08	--
Green foxtail	0.35	0.18
Smartweed	0.06	--
Russian thistle	0.02	0.15
Lamb's-quarter	0.02	0.06
Wild mustard	0.03	0.03
Canada thistle	0.01	0.01
Cleavers	0.19	0.10
Stinkweed	0.03	0.01
Stickseed	0.01	0.07
Bromegrass	--	0.01
Persian damel	--	0.27
Couchgrass	--	0.01
White mustard	--	0.07

¹ Wheat screening sample 1.

² Wheat screening sample 2.

Table 5. Chemical analysis and amino acid composition of wheat screening samples (as is).

	WS1 ¹		WS2 ²		Wheat ³	
	%	g/16 g of N	%	g/16 g of N	%	g/16 g of N
Moisture	12.04	--	12.02	--	8.30	--
Protein	15.77	--	15.19	--	13.08	--
Fat	2.36	--	2.63	--	1.83	--
Cystine	0.378	2.367	0.397	2.614	0.273	2.087
Aspartic acid + Asparagine	0.871	5.253	0.938	6.175	0.666	5.092
Methionine	0.237	1.503	0.263	1.731	0.183	1.399
Threonine	0.480	3.044	0.518	3.410	0.352	2.691
Serine	0.772	4.895	0.848	5.583	0.536	4.098
Glutamic acid + Glutamine	4.798	30.425	5.404	35.576	3.809	29.121
Proline	1.578	10.006	1.871	12.317	0.879	6.720
Glycine	0.661	4.192	0.709	4.668	0.537	4.106
Alanine	0.579	3.672	0.625	4.115	0.442	3.379
Valine	0.632	4.008	0.710	4.674	0.498	3.807
Isoleucine	0.518	3.285	0.586	3.858	0.398	3.043
Leucine	1.079	6.842	1.210	7.966	0.843	6.445
Phenylalanine	0.762	4.832	0.751	4.944	0.542	4.144
Histidine	0.481	2.651	0.524	3.449	0.383	2.928
Lysine	0.565	3.583	0.582	3.831	0.405	3.096
Arginine	0.856	5.428	0.952	6.267	0.611	4.671

¹ Wheat screening sample 1.

² Wheat screening sample 2.

³ Average of 16 wheat cultivars.

Table 6. AMEn (as is basis) and protein digestibility of wheat screenings fed to broiler chickens (Experiment 1).

	Treatment ¹		Probability	SEM
	WS1	WS2		
Ingredient AME _m (kcal/kg)	3107 ^a	3023 ^b	0.013	17.455
Ileal Protein Digestibility, (%)	83.3	80.4	NS	0.991
Dietary Moisture, (%)	9.16	9.29	--	--

¹ WS1 – wheat screening sample 1, WS2 – wheat screening sample 2.

^{a-b} Means within a row with no common superscript differ significantly (P<0.05).

Table 7. Digestibility of amino acids from wheat screenings fed to broiler chickens (Experiment 2).

	Treatment ¹		Probability	SEM
	WS 1	WS2		
	%			
Cystine	86.84	83.12	NS	0.014
Aspartic acid + Asparagine	89.06 ^a	80.55 ^b	0.0001	0.012
Methionine	90.99 ^a	87.48 ^b	0.002	0.006
Threonine	86.17 ^a	76.35 ^b	0.0001	0.013
Serine	89.58 ^a	82.43 ^b	0.0001	0.010
Glutamic acid + Glutamine	96.35 ^a	93.94 ^b	0.004	0.004
Proline	97.85 ^a	91.66 ^b	0.0001	0.008
Glycine	87.22 ^a	80.07 ^b	0.0001	0.010
Alanine	88.55 ^a	82.90 ^b	0.0003	0.009
Valine	90.06 ^a	81.91 ^b	0.0001	0.011
Isoleucine	93.07 ^a	81.05 ^b	0.0001	0.015
Leucine	92.88 ^a	84.08 ^b	0.0001	0.011
Phenylalanine	92.52 ^a	87.12 ^b	0.0001	0.008
Histidine	90.07 ^a	83.14 ^b	0.0001	0.009
Lysine	90.43 ^a	83.33 ^b	0.0001	0.010
Arginine	92.04 ^a	84.93 ^b	0.0001	0.010

¹ WS1 - wheat screening sample 1, WS2 - wheat screening sample 2.

^{a-b} Means within a row with no common superscript differ significantly ($P < 0.05$).

Table 8. Effect of wheat screenings on growth, feed efficiency, and performance of broiler chickens (experiment 2).

	Treatment ¹						Probability	SEM	A priori Contrasts ²			
	1	2	3	4	5	6			Ctrl vs			
									WS1 vs WS2	WS1+WS2	WS1 50% vs WS2 25%	
Body wt, 0d	0.044	0.044	0.044	0.044	0.043	0.044	NS	0.000	NS	NS	NS	
Body wt, 21d	0.752	0.743	0.732	0.730	0.742	0.743	NS	0.003	NS	NS	NS	
Body wt, 36d	1.851	1.838	1.826	1.820	1.855	1.856	NS	0.007	NS	NS	NS	
Avg Gain, 0-21d	0.708	0.699	0.688	0.686	0.699	0.699	NS	0.003	NS	NS	NS	
Avg Gain, 21-36d	1.099	1.095	1.095	1.090	1.112	1.113	NS	0.005	NS	NS	NS	
Avg Gain, 0-36d	1.807	1.794	1.783	1.776	1.811	1.811	NS	0.007	NS	NS	NS	
Avg FI, 0-21d	1.030	1.021	1.021	0.999	1.016	1.026	NS	0.005	NS	NS	NS	
Avg FI, 21-36d	2.086	2.045	2.011	1.974	2.089	2.056	NS	0.014	0.05	NS	NS	
Avg FI, 0-36d	3.130	3.082	3.051	2.989	3.116	3.082	NS	0.018	NS	NS	NS	
FtoGm, 0-21d	1.451	1.452	1.471	1.450	1.454	1.460	NS	0.003	NS	0.03	NS	
FtoGm, 21-36d	1.893	1.854	1.829	1.800	1.872	1.839	NS	0.010	NS	NS	NS	
FtoGm, 0-36d	1.718	1.696	1.689	1.664	1.710	1.692	NS	0.006	NS	NS	NS	
FtoG, 0-21d	1.457	1.462	1.486	1.457	1.454	1.468	NS	0.003	NS	0.04	NS	
FtoG, 21-36d	1.915	1.889	1.862	1.831	1.891	1.862	NS	0.011	NS	NS	NS	
FtoG, 0-36d	1.733	1.719	1.713	1.683	1.720	1.708	NS	0.007	NS	NS	NS	
Mort %, 0-21d	1.52	1.82	1.82	1.21	0.00	0.61	NS	0.219	0.01	NS	NS	
Mort %, 21-36d	1.21	1.52	1.82	1.52	0.91	1.21	NS	0.255	NS	NS	NS	
Mort %, 0-36d	2.73	3.33	3.64	2.73	0.91	1.82	NS	0.318	0.01	NS	NS	

1-control, no wheat screenings; 2-25% wheat screening; 3-50% wheat screenings; 4-Total wheat replacement by wheat screenings; 5-25% wheat screenings; 6-25% wheat screenings; 7-25% wheat screenings; 8-25% wheat screenings; 9-25% wheat screenings; 10-25% wheat screenings; 11-25% wheat screenings; 12-25% wheat screenings; 13-25% wheat screenings; 14-25% wheat screenings; 15-25% wheat screenings; 16-25% wheat screenings; 17-25% wheat screenings; 18-25% wheat screenings; 19-25% wheat screenings; 20-25% wheat screenings; 21-25% wheat screenings; 22-25% wheat screenings; 23-25% wheat screenings; 24-25% wheat screenings; 25-25% wheat screenings; 26-25% wheat screenings; 27-25% wheat screenings; 28-25% wheat screenings; 29-25% wheat screenings; 30-25% wheat screenings; 31-25% wheat screenings; 32-25% wheat screenings; 33-25% wheat screenings; 34-25% wheat screenings; 35-25% wheat screenings; 36-25% wheat screenings; 37-25% wheat screenings; 38-25% wheat screenings; 39-25% wheat screenings; 40-25% wheat screenings; 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¹ 1-control, no wheat screenings; 2-25% wheat screening 1; 3-50% wheat screenings 1; 4-Total wheat replacement by wheat screenings 1; 5-25% wheat screenings 2; 6-50% wheat screenings 2.

² wheat screenings 1 vs wheat screenings 2; control vs wheat screenings 1 and 2; wheat screenings 1 at 50% vs wheat screenings 1 at 25%; wheat screenings 2 at 50% vs wheat screenings 2 at 25%.

Avg Gain - average gain; Avg FI - average feed intake; FtoGm - feed to gain ratio corrected for mortality; FtoG - feed to gain ratio; Mort - mortality.

Table 9. Effect of wheat screenings on feed intake and body weight gain of laying hens (Experiment 4).

	Feed Intake (kg/day/hen)				Body Weight (kg)		
	Period				Weeks of age		
	20 - 24	24 - 28	28 - 32	32 - 35	20	30	35
Control	0.0921	0.1036	0.1051 ^{ab}	0.1110 ^a	1.474	1.605	1.687
25% WS1	0.0950	0.1059	0.1082 ^a	0.1135 ^a	1.509	1.637	1.733
50% WS1	0.0910	0.1009	0.1030 ^b	0.1088 ^{ab}	1.473	1.606	1.689
25% WS2	0.0923	0.1042	0.1081 ^a	0.1101 ^{ab}	1.478	1.623	1.688
50% WS2	0.0918	0.1014	0.1034 ^b	0.1053 ^b	1.471	1.606	1.676
SEM	0.0011	0.0010	0.0010	0.0012	0.010	0.011	0.012
	NS	NS	0.05	0.05	NS	NS	NS
Line A	0.0985 ^a	0.1088 ^a	0.1104 ^a	0.1157 ^a	1.539 ^a	1.672 ^a	1.752 ^a
Line B	0.0863 ^b	0.0976 ^b	0.1007 ^b	0.1038 ^b	1.423 ^b	1.558 ^b	1.637 ^b
	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Strain x Diet	NS	NS	NS	NS	NS	NS	NS

^{a-b} Means within a column with no common superscript differ significantly ($P < 0.05$).

Table 10. Effect of wheat screenings on egg production, feed efficiency, egg weight, specific gravity, haugh unit, and mortality of laying hens.

	HDP ¹	HHP ²	FEM ³	FDE ⁴	Overall Egg Weight	Overall Specific Gravity	Haugh Unit at 35 week of age	Mortality
	%		kg		g			%
Diet 1, Control	90.54	88.78	2.0798	1.3656 ^{abc}	54.70	1.0845	85.478	3.33
Diet 2, 25% WSI	90.84	88.68	2.0810	1.3930 ^a	55.59	1.0840	86.643	4.00
Diet 3, 50% WSI	90.68	90.08	2.0533	1.3359 ^{bc}	54.21	1.0837	84.552	2.00
Diet 4, 25% WS2	90.46	88.93	2.0931	1.3745 ^{ab}	54.71	1.0840	86.876	3.33
Diet 5, 50% WS2	90.93	90.55	2.0277	1.3274 ^c	54.52	1.0840	86.287	1.33
SEM	0.347	0.453	0.009	0.010	0.3187	0.0003	0.4137	0.810
	NS	NS	NS	0.01	NS	NS	NS	NS
Line A	91.14 ^a	89.96	2.0832	1.4134 ^a	56.53 ^a	1.0854 ^a	86.956 ^a	4.80 ^a
Line B	89.24 ^b	88.85	2.0543	1.3052 ^b	52.95 ^b	1.0826 ^b	84.978 ^b	0.80 ^b
	0.01	NS	NS	0.05	0.01	0.01	0.05	0.05
Strain x Diet	NS	NS	NS	NS	NS	NS	NS	NS

a, b, c Means within a column with no common superscript differ significantly (P<0.05).

¹ Hen Day Production.

² Hen Housed Production.

³ Feed per Egg Mass.

⁴ Feed per Dozen Eggs.

D. Equipment

NONE

E. Project Developed Materials

NONE

F. Project Photos

NONE

G. Acknowledgement

Financial contributions of the Saskatchewan Agriculture and Food TAD program, the Saskatchewan Egg Producers and the Saskatchewan Wheat Pool, and donation of wheat screenings by North West Terminal, Unity, Saskatchewan and AgPro Ltd., Saskatoon, Saskatchewan are gratefully acknowledged.

H. Communication of Results

The results of this research will be presented to the Chicken Farmers of Saskatchewan this fall. Results from the laying hen trial will be presented to industry at an extension meeting. A scientific manuscript of the experiments is near completion. Copies of the final report have been sent to sponsoring organisations.